N88-11040

TEST SUMMARY FOR ADVANCED H_2 CYCLE NI-CD CELL

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ABSTRACT

To improve operational tolerances and mass, the H_2 gas recombination design provisions of the Ni-H_2 system have been incorporated into the sealed Ni-Cd system. Produced is a cell design capable of operating on the "H_2 cycle" versus the normal "O_2 cycle". Three (3) test cells have now completed approximately 4,300 LEO (90 minute) cycles at 20% DOD. Performance remains stable although one (1) cell exhibited a temporary pressure anomaly.

INTRODUCTION

This paper is intended as a test summary update on a small group of cells which evolved from development efforts previously reported in the NASA/GSFC Battery Workshop.(1)

Three (3) 50 AH rated, space type, Ni-Cd battery cells were equipped with standard, Ni-H_2 type, catalytic gas electrodes as shown in Exhibit No. 1. These cells incorporated no discharged negative electrode capacity or "overcharge protection". H_2 gas evolution at the negative electrode during charge is expected and intended in this design.

By connecting (electrically) the cell case directly to the cell positive terminal, the evolved H_2 gas would be expected to be recombined rapidly by the reactions summarized in Exhibit No. 2.

DESIGN ADVANTAGES

If the concept proves successful, it is believed the design will offer the advantages listed in Exhibit No. 3. These advantages should allow the production of a sealed Ni-Cd cell design which can tolerate higher charge rates over a wider temperature range while offering a longer cycle life at a higher DOD.

In addition, a lower mass or improved specific energy should be achieved by elimination of the present weight associated with the negative electrode discharged or overcharge protection capacity increment. This improvement relative to a current "O_2 cycle" cell design is summarized in Exhibit No. 4.

TEST SUMMARY

The three (3) 50 AH rated cells were equipped with pressure gages and mounted in a thermal control system. Shorting straps were connected from the positive terminal of each cell to its case. The charge/discharge cycle was controlled automatically to a fixed time at a constant current. A limited test budget necessitated manual data acquisition which imposed the need for some data extrapolation to the actual end point.

Test parameters and major events are summarized in Exhibit No. 5. In general, stable performance continues to be maintained.

The capacity measurements were performed via reconditioning cycles from a fully charged state.

Because of pressure recovery, no examination of the one (1) anomalous cell has been performed yet to determine the cause of its performance diversion. It is suspected in these "first build" test cells a high resistance may have temporarily developed in the catalytic electrode-to-positive electrode circuit.

Test data was only summarized to approximately cycle number 3,360 because a large group of cells from another program were introduced into the thermal control system. A higher test temperature required by the large group of cells precludes a direct comparison with the earlier cycle data.

CONCLUSION

Testing is continuing on a small group of "H_2 cycle", sealed Ni-Cd cell designs with successful results. To date, 4,300 LEO cycles have been achieved at a 20% DOD.

The goal is to demonstrate concept feasibility leading to the production of an advanced sealed, Ni-Cd cell design offering improved operational tolerance and lower mass.

REFERENCES

(1) Miller, L. (Eagle-Picher Industries): "An Advanced Ni-Cd Battery Cell Design". Proc. 1985 Goddard Space Flight Center Battery Workshop, NASA Conference Publication 2434, GSFC Greenbelt, Maryland, November 19-21, 1985.

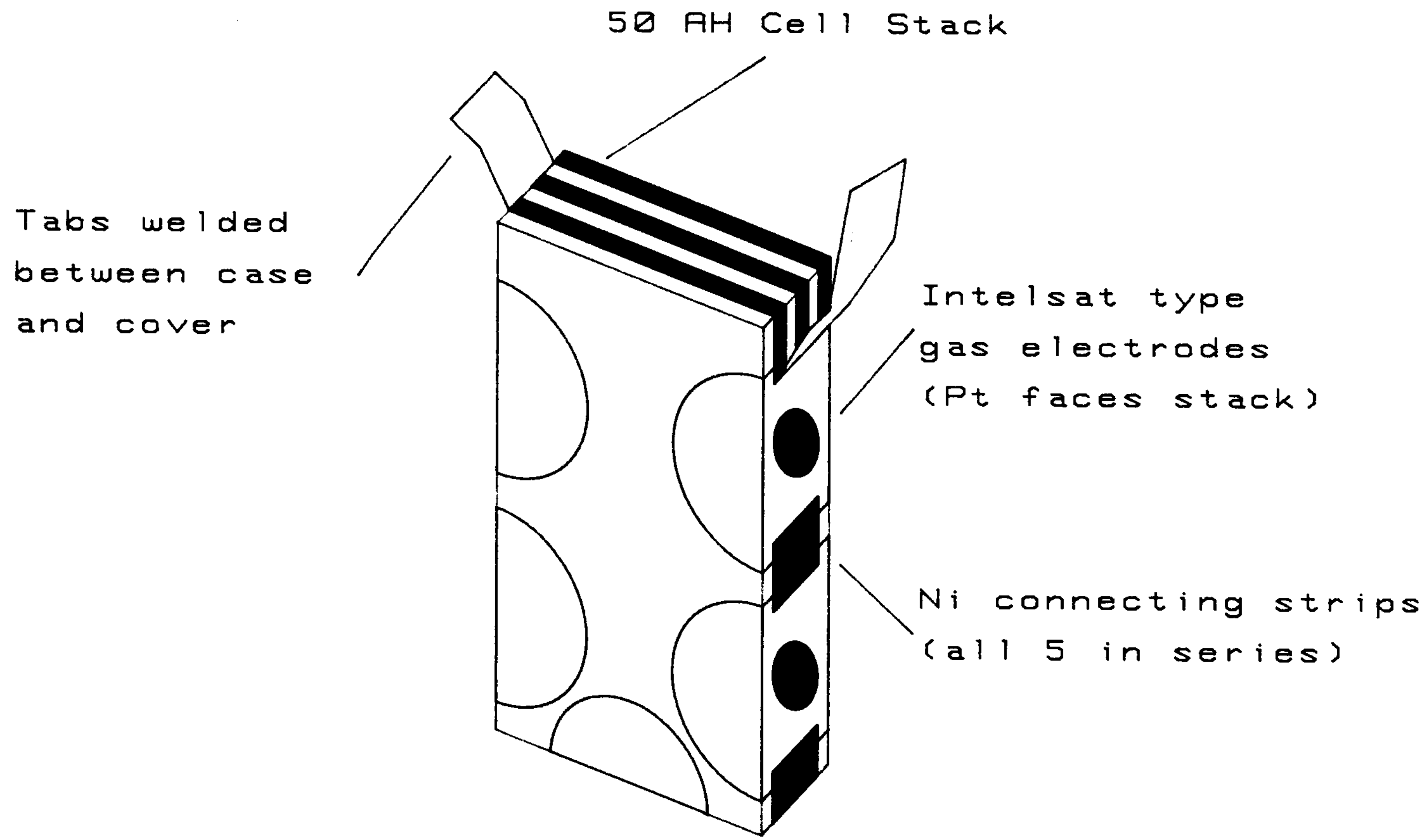

Figure 1. Ni-Cd Test Cell Assembly Sketch.

$$1. \quad H_2 + 2\ OH^- \rightarrow [2\ H_2O + 2e^-]$$

$$2. \quad 2\ NiOOH + [2\ H_2O + 2e^-] \rightarrow 2\ Ni(OH)_2 + 2\ OH^-$$

COMBINED REACTION

$$3. \quad 2\ NiOOH + H_2 \rightarrow 2\ Ni(OH)_2$$

Figure 2. Sealed Nickel–Cadmium Gas Electrode Reaction.

1. INCREASED OPERATIONAL TOLERANCE.
2. ACCOMMODATE INORGANIC SEPARATOR CANDIDATES.
3. FUNCTION WITH INCREASED ELECTROLYTE QUANTITIES.
4. LOWER OPERATING PRESSURES.
5. HIGHER SPECIFIC ENERGIES.

Figure 3. H_2 Cycle Ni-Cd Cell Design Advantages.

	O_2 CYCLE	H_2 CYCLE
POSITIVE GROUP	456 GMS	456 GMS
NEGATIVE GROUP	633	508*
ELECTROLYTE	223	223
SEPARATOR	18	18
CELL COVER	25	25
CELL CAN	98	98
TOTAL	1,453 GMS	1,328 GMS
SPECIFIC ENERGY	45.4 WHR/KG	49.7 WHR/KG

* ASSUMPTIONS:

1. NEGATIVE/POSITIVE RATIO = 1.8:1.0
2. REMOVED DISCHARGED NEGATIVE CAPACITY (OVERCHARGE PROTECTION) = 125 GRAMS (70% OF EXCESS CAPACITY)

Figure 4. Light-Weight 50 AH Ni-Cd Cell Design.

CHARGE:	60 MINUTES/10.0 AMPS
DISCHARGE:	36 MINUTES/16.0 AMPS
RETURN:	1.04 FACTOR
TEMPERATURE:	$10^{o}C$
CYCLES TO DATE:	4,300
DOD:	APPROXIMATELY 20%

MAJOR EVENTS:

I.	INITIAL PERFORMANCE	-	(APPROX. CYCLE 30)
	END-OF-CHARGE $\bar{X}$	=	1.68 VOLTS
	END-OF-DISCHARGE $\bar{X}$	=	1.24 VOLTS
	END-OF-CHARGE PRESSURE $\bar{X}$	=	-20 IN. OF HG
II.	CAPACITY MEASUREMENT	-	(APPROX. CYCLE 500)
	MEASURED CAPACITY $\bar{X}$	=	59.0 AH
III.	CAPACITY MEASUREMENT	-	(APPROX. CYCLE 1,500)
	MEASURED CAPACITY $\bar{X}$	=	58.0 AH

Figure 5. Life Test Summary.

IV. TEST ANOMALY - (APPROX. CYCLE 2,800)

ONE (1) CELL PRESSURE DIVERSION (END-OF-CHARGE)

APPROX. CYCLE	PRESSURE
2,800	-21 IN. OF HG
2,930	64 PSI
3,050	81 PSI
3,180	33 PSI
3,310	-18 IN. OF HG

V. CURRENT PERFORMANCE - (APPROX. CYCLE 3,360)

END OF CHARGE $\bar{X}$ = 1.67 VOLTS

END OF DISCHARGE $\bar{X}$ = 1.23 VOLTS

END OF CHARGE PRESSURE $\bar{X}$ = -22 IN. OF HG

Figure 5. Continued.